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A new method and composition for cleaning metal surfaces has been developed. The mixture consisting of a water soluble polymer, preferably polyvinylpyrrolidone (PVP), and a chelating agent can be applied to a rusty metal surface as a thick paste. The outer surface of the paste gradually hardens into an encapsulating film entrapping the cleaning agents inside and in contact with the rust until the surface is clean. After cleaning, the tape-like coating can be easily peeled from the cleaned surface and disposed of as a solid waste. Advantages of the new system include: economical and environmentally safe ingredients; and the ability to clean irregular surfaces and overhead objects found on ships, i.e., high-temperature valves, pipes and the like, without sandblasting or washing procedures.		

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A NEW METHOD AND COMPOSITION FOR CLEANING METAL SURFACES

INTRODUCTION

New protective coatings and new coating technologies are destined to play an important role in drastically reducing maintenance and extending the useful life of many naval vessels. In contrast, the surface cleaning and pretreatment technology required to insure the integrity of coatings has shown little improvement, despite indications that 90% of all coating failures occur because current pretreatment methods are inadequate. Consequently, NRL has directed its attention to the development of new cleaning chemicals and procedures that can be safely applied to surfaces aboard ship and efficiently prepare the surface so that coatings can fully exhibit their protective properties.

THE PRINCIPLES OF A NEW SURFACE CLEANING TECHNOLOGY

Because a protective coating is only as good as the surface onto which it is applied, a major portion of the time spent in applying the protective system must be devoted to surface preparation before the final coating is applied. A drastically different approach to surface cleaning which will greatly reduce the time spent on preparing a good surface is being investigated by the Solution Chemistry Section, Naval Research Laboratory. The new procedure consists of the following steps: (a) a mixture of a water-soluble organic polymer and chelant is applied to the

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dirty, corroded surface; (b) a plastic film forms that encapsulates the cleaning ingredients; (c) the metal ions dissolved by the chelant and possibly the polymer causes the polymer to cross-polymerize and then cure to a thick plastic film; (d) the hardened film, which contains the corrosion products and protects the clean surface from rusting, is peeled from the surface like a strip of tape and treated as solid waste; and (e) a permanent protective coating is applied to the clean surface.

A CLEANING FORMULATION FOR IRON SURFACES

Although the development of methods and compositions for cleaning formulations is continuing, a brief report of our current investigations is required now that a patent application has been submitted (1) and news items released (2). An especially successful cleaning formulation is one using polyvinylpyrrolidone (PVP) and ethylenediaminetetraacetic acid (EDTA) to form a thick paste which is then applied onto the metal surface to be cleaned. The general procedure to be described is currently being developed to clean rust from low-carbon steel surfaces.

1. The Chelating Agent

A number of chelating agents which are capable of forming strong complexes with iron were investigated. These included: ethylenediaminetetraacetic acid (EDTA); nitrilotriacetic acid; iminodiacetic acid; hydroxyethyliminodiacetic acid; etc. The various sodium salts of these acids were often chosen to study pH effects. The chelating agents were used in an amount of 1 to 10 weight percent of the entire solution. After many tests, EDTA was selected as the preferred chelating agent for the iron system being investigated.

2. The Polymer

A water soluble polymer which could be cross-linked with iron ions was sought: methacrylic or acrylic acid polymers were investigated, but the water soluble polyvinylpyrrolidone (PVP) was found most effective. Polymers having an average molecular weight of between 10,000 to 500,000

were investigated. PVP having a molecular weight of 360,000 and available from GAF as PVP K-90 was found to be particularly suitable for iron surfaces. A 5 to 30 weight percent solution or paste of the polymer was used. We believe that iron existing in different oxidation states forms a chelate with polymer chains and thereby joins them to form an insoluble, high molecular weight, metal containing cross-linked polymer.

Various wetting agents were included in the composition to better wet the surface to be cleaned. The exact amounts of the various components in the cleaning formulation is influenced by the amount of rust present on the surfaces, the humidity and temperature of the surrounding environment, and the time restraints involved in cleaning and coating the surface.

AN EXPLANATION OF THE CLEANING PROCESS

The cleaning process is illustrated in Figures 1 through 6. A typical iron surface consists of the iron substrate upon which a layer of magnetite (Fe_3O_4) and Fe_2O_3 (rust) are formed (Figure 1). After the cleaning formulation is applied in the form of a thick paste (Figure 2), the cleaning composition divides into a solution in contact with the dirty surface and a polymeric film which encapsulates the cleaning fluid in place (Figure 3). The applied cleaning material is allowed to clean and become hard over a period of 2 to 24 hours (with PVP, preferably 8 to 12 hours at about 75°F). Now, a thick strip of plastic material protects the clean metal surface and contains the iron ions from the dissolved rust as well as any loose material (Figure 4). When the cured cleaning material is peeled away (Figure 5), a clean metal surface will remain with a thin adherent magnetite layer protecting the surface from rusting prior to the application of a permanent protective coating (Figure 6).

ADVANTAGES OF THE NEW SURFACE CLEANING TECHNOLOGY

The advantages of our new cleaning formulation and technique are substantial. A metal surface now can be effectively and easily cleaned with a minimum of effort. In fact, the formulation can be applied as soon as rust is observed and the painting process delayed until a large number of areas are to be painted. Just prior to application the plastic is removed and, without further washing, the protective coating applied. However,

if a large area is cleaned, the thin adherent layer of magnetite that remains will protect the surface from rusting until the protective coating is applied. Finally, the chemicals suggested for iron surfaces are both economical and non-toxic and the polymeric film formed can be disposed of easily and safely as solid waste.

FUTURE WORK

Many modifications and variations of the formulation reported for iron surfaces are possible. We are currently investigating the mechanism of the reactions which are important in the encapsulating, solublizing, hardening and peeling steps of the new process. In addition, we are developing formulations for Navy applications requiring specific characteristics for the area of application, metal, temperature, humidity, and the surface quality necessary for applying the final protective coating.

ACKNOWLEDGMENT

We wish to express our thanks to the GAF Corporation for samples of polyvinylpyrrolidone used to develop our method.

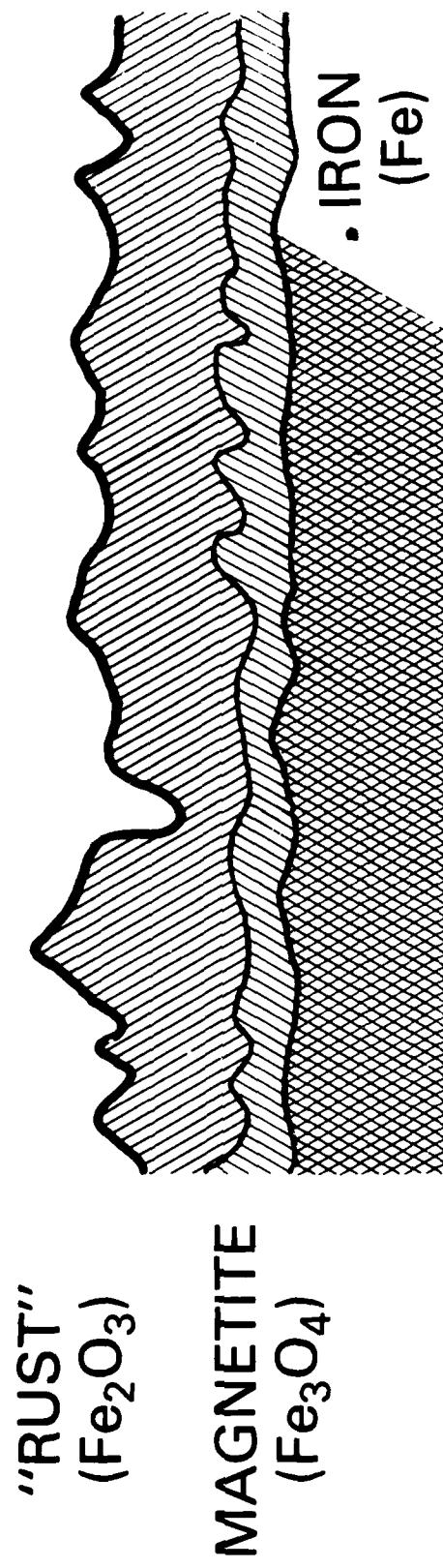


Fig. 1 — Rusted iron surface



Fig. 2 — Application of PVP/EDTA cleaning formulation to rusty iron surface

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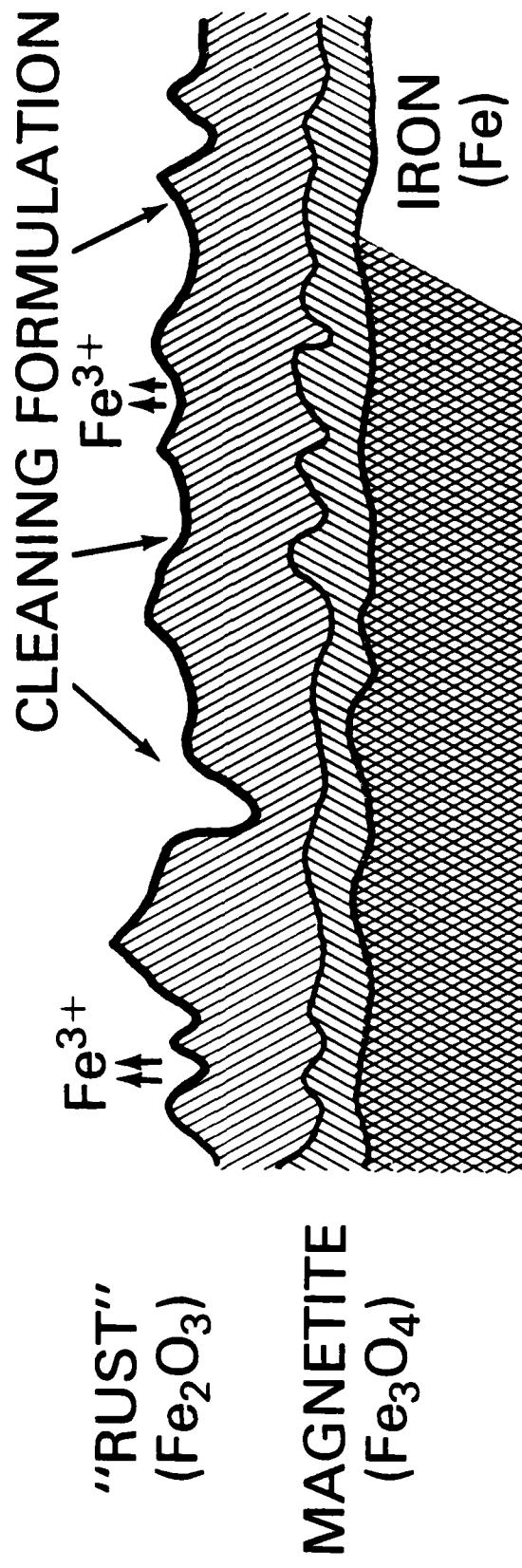


Fig. 3 — Encapsulating process with film holding cleaning formulation in contact with the rust

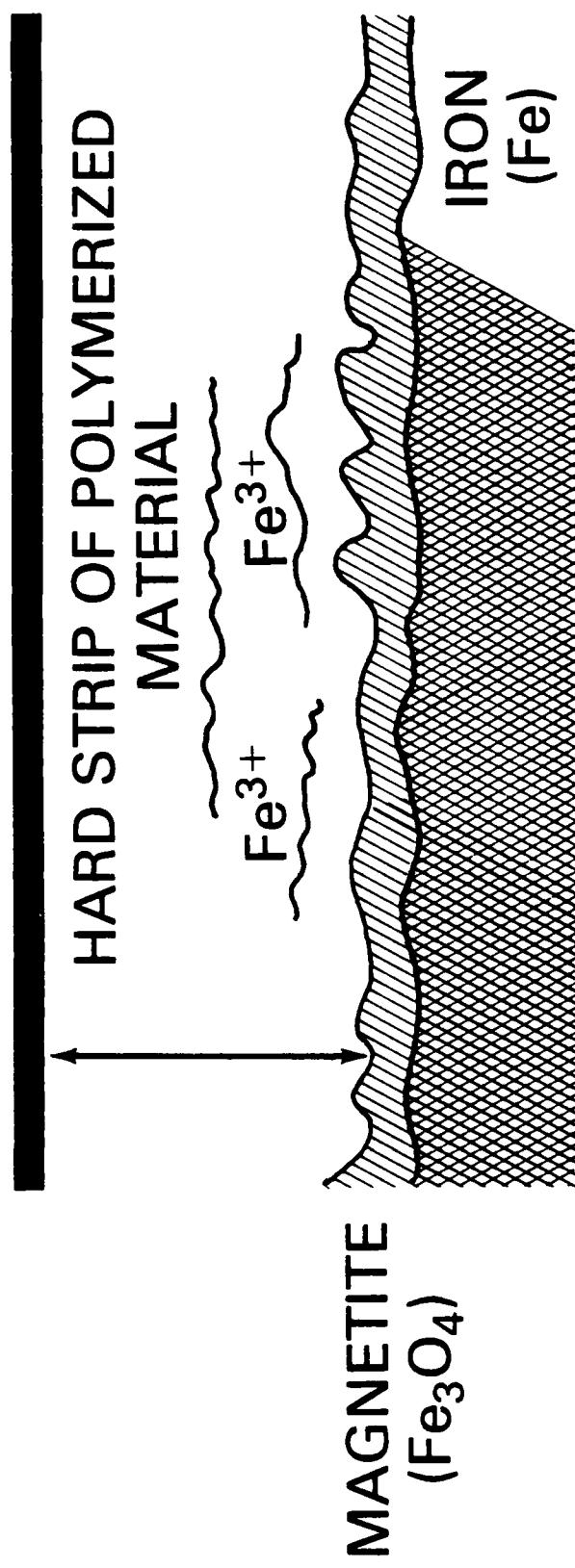


Fig. 4 — Cleaning process is complete and the film protects the iron surface



Fig. 5 — Removal of cleaning strip which contains the rust and other corrosion products

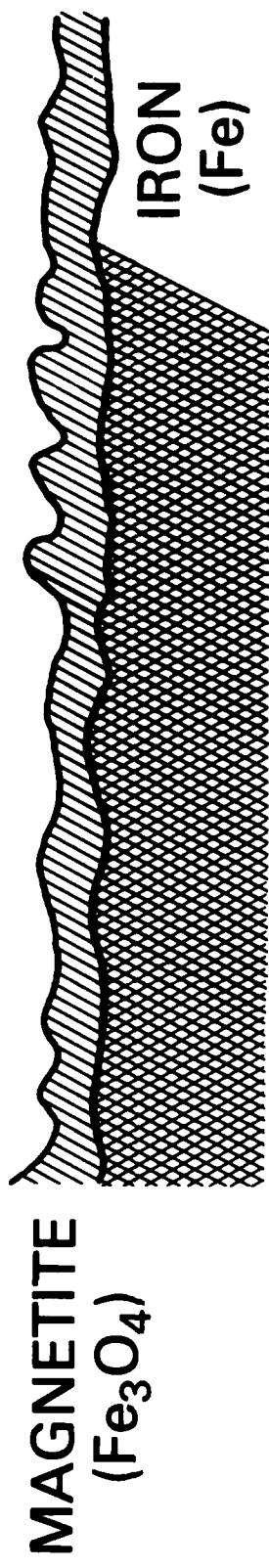


Fig. 6 — Clean iron surface with protective magnetite layer

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